EVA 007-ENERGY CONSERVATION , MANAGEMENT AND AUDIT

OBJECTIVES

- To minimise energy costs / waste without affecting production & Quality
- To minimise environmental effects
- Understand and analyse the energy data of industries
- Carryout energy accounting and balancing
- Conduct energy audit and suggest methodologies for energy savings
- Utilise the available resources in optimal ways

UNIT - 1 ENERGY SCENARIO

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them.

Energy is the ability to do work and work is the transfer of energy from one form to another. In practical terms, energy is what we use to manipulate the world around us, whether by exciting our muscles, by using electricity, or by using mechanical devices such as automobiles. Energy comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy.

Energy can be classified into several types based on the following criteria:

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy

Primary and Secondary Energy

Primary energy sources are those that are either found or stored in nature. Common primary energy sources are coal, oil, natural gas, and biomass (such as wood). Other primary energy sources available include nuclear energy from radioactive substances, thermal energy stored in earth's interior, and potential energy due to earth's gravity

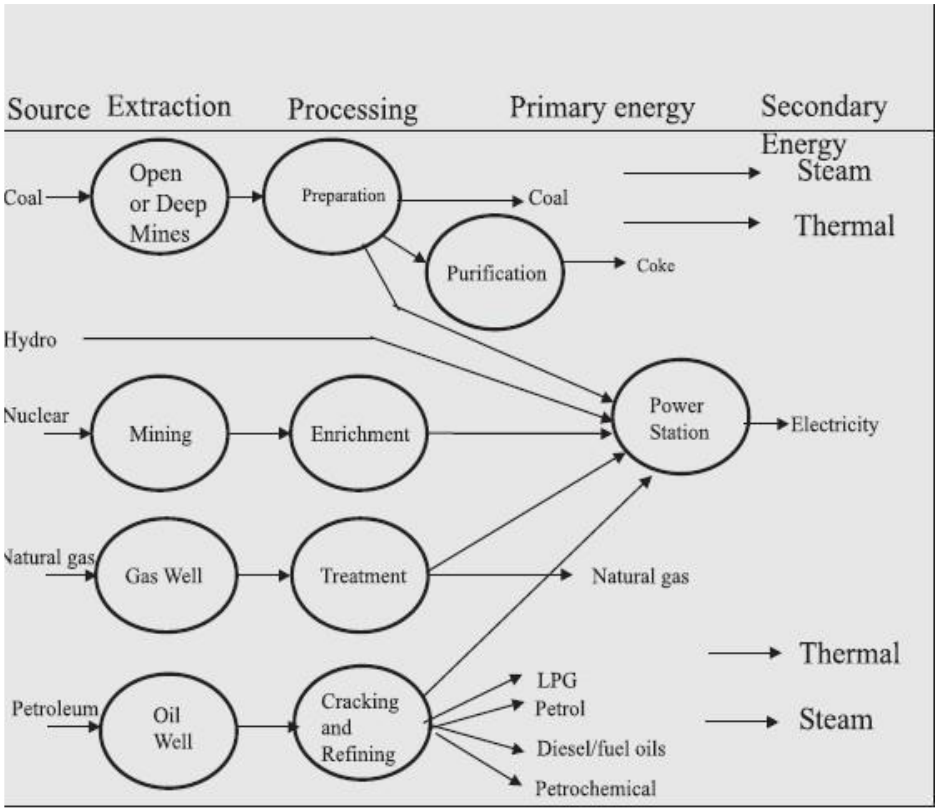


Figure 1.1 Major Primary and Secondary Sources

Primary energy sources are mostly converted in industrial utilities into secondary energy sources; for example coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non-energy uses, for example coal or natural gas can be used as a feedstock in fertilizer plants.

1.1.2 Commercial Energy and Non Commercial Energy

Commercial Energy

The energy sources that are available in the market for a definite price are known as commercial energy. By far the most important forms of commercial energy are electricity, coal and refined petroleum products. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In the industrialized countries, commercialized fuels are predominant source not only for economic production, but also for many household tasks of general population.

Examples: Electricity, lignite, coal, oil, natural gas etc.

Non-Commercial Energy

The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price

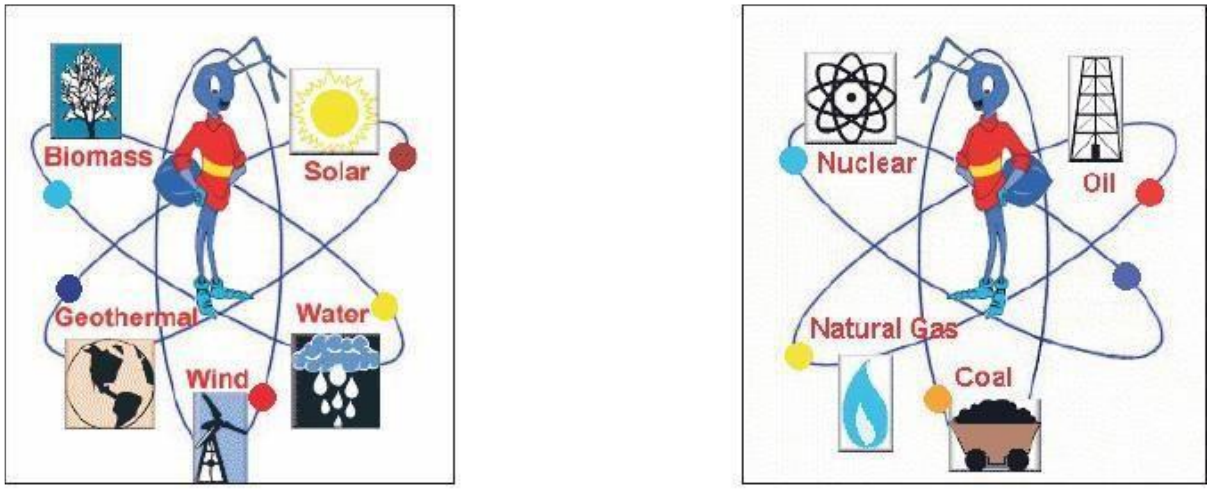
used especially in rural households. These are also called traditional fuels. Non- commercial energy is often ignored in energy accounting.

Example: Firewood, agro waste in rural areas; solar energy for water heating, electricity generation, for drying grain, fish and fruits; animal power for transport, threshing, lifting water for irrigation, crushing sugarcane; wind energy for lifting water and electricity generation.

1.1.3 Renewable and Non-Renewable Energy

Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power (See Figure 1.2). The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.

Non-renewable energy is the conventional fossil fuels such as coal, oil and gas, which are likely to deplete with time.



Renewable Non-Renewable

Figure 1.2 Renewable and Non-Renewable Energy

1.2Energy and Power

1.2.1 Energy

Energy is the ability to do a work. Its unit is Joule (J)

Energy = force * Distance

1.2.2 Power

Power is defined as the rate of doing work. Its unit is watt (W)

1.2.3 Relation Between Energy and Power

Energy = Power * Time

Example 1.1
A portable machine requires a force of 200N to move it. How much work is done if the machine is moved 20m and what average power is utilized if the movement takes 25s?
Solution
Work done = force * distance
= 200N * 20m
= 4000 Nm or 4 kJ
Power = work done / time taken = 4000 J / 25 s = 160 J/s = 160 W

1.3 Present and Past Scenario of Primary Energy Resources In The World

1.3.1 Coal

Coal is the most abundant fossil fuel in the world. Coal reserves are available in almost every country in the world. The largest coal reserves are available in the USA followed by Russia, China, Australia and India. The global coal reserve was estimated to be **891.531 billion tones by the end of 2013**. But by the end of **2003, it was estimated to be 984.453 billion tones**.

1.3.2 Crude Oil

The global proven crude oil reserve was estimated to be **1687 billion barrels by the end of 2013**. But by the end of **2003, it was estimated to be 1147 billion barrels**. Almost 48% of proven oil reserves are in the Middle East countries. Saudi Arabia has the largest share of the reserve with 15.8% followed by Russia and USA

1.3.3 Natural Gas

Natural gas is a gaseous fossil fuel consisting primarily of methane but also includes small quantities of ethane, propane, butane and pentane. Before natural gas can be used as a fuel, it undergoes extensive processing for removing almost all constituents except methane. Natural gas resources are large but they are highly concentrated in few countries. Iran has largest share (18.2%) followed by Russia (16.8%) and Qatar (13.3%). India has only about 0.7% of global natural reserves. The global proven natural gas reserve was estimated to be **176 trillion cubic meters by the end of 2003**. But by the end of 2013**, it was estimated to be 186 trillion cubic meters**.

1.4 National Energy Consumption Data

The primary energy consumption of some of the countries are given in table. It is seen that India's primary energy consumption is only 4.7% of the world (USA-18%, China-22%).

Table-1.7 Primary Energy consumption at the end of 2013								
	Million tonnes of oil equivalent (Mtoe)							% of Share
Country	Oil	Natural gas	Coal	Nuclear Energy	Hydro-Power	Renewable Energy	Total	
China	507.4	145.5	1925.3	25	206.3	42.9	2852.4	22.4
US	831.0	671.0	455.7	187.9	61.5	58.6	2265.8	17.8
Russia	153.1	372.1	93.5	39.1	41	0.1	699	5.5
India	175.2	46.3	324.3	7.5	29.8	11.7	595.0	4.7
Japan	208.9	105.2	128.6	3.3	18.6	9.4	474.0	3.7
Germany	112.1	75.3	81.3	22.0	4.6	29.7	325.0	2.6
Others	2197.4	1198.3	818	278.4	494	126.9	5519.2	43.3
World	**4185.1**	**3030.4**	**3826.7**	**563.2**	**855.8**	**279.3**	**12730.4**	**100**

Source: BP Statistical Review of World Energy, June 2014

1.5Environmental Aspects Associated with energy utilization

The usage of energy resources in industry leads to environmental damages by polluting theatmosphere. Few of examples of air pollution are sulphur dioxide (SO2), nitrous oxide (NOX) and carbon monoxide (CO) emissions from boilers and furnaces, chloro-fluro carbons (CFC) emissions from refrigerants use, etc. In chemical and fertilizers industries, toxic gases are released. Cement plants and power plants spew out particulate matter.

Air Pollution

In both developed and rapidly industrializing countries, the major historic air pollution problem has typically been high levels of smoke and SO2 arising from the combustion of sulphur-containing fossil fuels such as coal for domestic and industrial purposes.

In both developed and developing countries, the major threat to clean air is now posed by traffic emissions. Petrol- and diesel-engined motor vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs) and particulates, which have an increasing impact on urban air quality.

In addition, photochemical reactions resulting from the action of sunlight on NO2 and VOCs from vehicles leads to the formation of ozone, a secondary long-range pollutant, which impacts in rural areas often far from the original emission site. Acid rain is another long-range pollutant influenced by vehicle NOx emissions.

The principle pollutants produced by industrial, domestic and traffic sources are sulphur dioxide, nitrogen oxides, particulate matter, carbon monoxide, ozone, hydrocarbons, benzene, 1,3- butadiene, toxic organic micro pollutants, lead and heavy metals

1.5.2 Climate Change

Human activities, particularly the combustion of fossil fuels, have made the blanket of greenhouse gases (water vapour, carbon dioxide, methane, ozone etc.) around the earth thicker. The resulting increase in global temperature is altering the complex web of systems that allow life to thrive on earth such as rainfall, wind patterns, ocean currents and distribution of plant and animal species.

1.5.3 Greenhouse Effect and Carbon Cycle

Life on earth is made possible by energy from the sun, which arrives mainly in the form of visible light. About 30 percent of the sunlight is scattered back into space by outer atmosphere and the balance 70 percent reaches the earth's surface, which reflects it in form of infrared radiation. The escape of slow moving infrared radiation is delayed by the green house gases. A thicker blanket of greenhouse gases traps more infrared radiation and increase the earth's temperature

Carbon dioxide is responsible for 60 percent of the "enhanced greenhouse effect". Humans are burning coal, oil and natural gas at a rate that is much faster than the rate at which these fossil fuels were created. This is releasing the carbon stored in the fuels into the atmosphere and upsetting the carbon cycle (a precise balanced system by which carbon is exchanged between the air, the oceans and land vegetation taking place over millions of years). Currently, carbon dioxide levels in the atmospheric are rising by over 10 percent every 20 years.

The effects of increase in the earth's temperature are as follows:

- **Severe Storms and Flooding**
- **Food Shortages**
- **Reduced Freshwater supply**
- **Loss of Biodiversity**
- **Increased Diseases**

1.5.4 Acid Rain

- Acid rain is caused by release of SOX and NOX from combustion of fossil fuels, which then mix with water vapour in atmosphere to form sulphuric and nitric acids respectively.

- The effects of acid rain are as follows:
- Acidification of lakes, streams, and soils
- Direct and indirect effects (release of metals, For example: Aluminum which washes away plant nutrients)
- Killing of wildlife (trees, crops, aquatic plants, and animals)
- Decay of building materials and paints, statues, and sculptures
- Health problems (respiratory, burning- skin and eyes)

1.6 Energy Auditing

- As per the Energy Conservation Act, 2001, Energy Audit is defined as "***the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption***".

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

- To minimize energy costs / waste without affecting production & quality
- To minimize environmental effects.

1.7 Energy Audit: Needs

- In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.
- The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.
- In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

- The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a " bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization

1.8 Energy Audit: Types

Type of Energy Audit

The type of Energy Audit to be performed depends on:

- .Function and type of industry
- .Depth to which final audit is needed, and
- .Potential and magnitude of cost reduction desired
- Thus Energy Audit can be classified into the following two types.

  i) Preliminary Audit

  ii) Detailed Audit

Preliminary Energy Audit Methodology

- Preliminary energy audit is a relatively quick exercise to:
- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

Detailed Energy Audit Methodology

- A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.
- This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.
- In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions

and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases: Phase I, II and III.

- Phase I - Pre Audit Phase
- Phase II - Audit Phase Phase III - Post Audit Phase

Phase I -Pre Audit Phase Activities

A structured methodology to carry out an energy audit is necessary for efficient working. An initial study of the site should always be carried out, as the planning of the procedures necessary for an audit is most important.

Initial Site Visit and Preparation Required for Detailed Auditing

An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit.

During the initial site visit the Energy Auditor/Engineer should carry out the following actions: -

• Discuss with the site's senior management the aims of the energy audit.

• Discuss economic guidelines associated with the recommendations of the audit.

• Analyze the major energy consumption data with the relevant personnel.

• Obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.

• Tour the site accompanied by engineering/production

The main aims of this visit are: -

• To finalize Energy Audit team

• To identify the main energy consuming areas/plant items to be surveyed during the audit.

• To identify any existing instrumentation/ additional metering required.

• To decide whether any meters will have to be installed prior to the audit eg. kWh, steam, oil or gas meters.

To identify the instrumentation required for carrying out the audit.

• To plan with time frame

• To collect macro data on plant energy resources, major energy consuming centers

• To create awareness through meetings/ programme

Phase II- Detailed Energy Audit Activities

Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked.

The audit report will include a description of energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary assessment of the cost of the improvements will be made to indicate the expected pay- back on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be per- formed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes: -

1. Energy consumption by type of energy, by department, by major items of process equipment, by end-use

2. Material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use in other industries, etc.)

3. Energy cost and tariff data

4. Process and material flow diagrams

5. Generation and distribution of site services (eg. compressed air, steam).

6. Sources of energy supply (e.g. electricity from the grid or self-generation)

7. Potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation).

8. Energy Management procedures and energy awareness training programs within the establishment

1.9 Energy Audit -Methodology

A comprehensive ten-step methodology for conduct of Energy Audit at field level is presented below. Energy Manager and Energy Auditor may follow these steps to start with and add/change as per their needs and industry types

Ten Steps Methodology for Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	Phase I –Pre Audit Phase	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices
Step 2	• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation
	Phase II –Audit Phase	
Step 3	• Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.
Step 5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc.

		- Boiler/Efficiency trials for (4 – 8 hours) - Furnace Efficiency trials Equipments Performance experiments etc
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology
Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	• Documentation, Report Presentation to the top Management.
	<u>Phase III –Post Audit phase</u>	
Step10	• Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

1.10 Barriers to Energy Conservation

Traditional energy prices are understated because they do not include the health, social, and environmental costs of using fuels. For example, gasoline prices do not take into account the costs associated with military requirements to protect access to oil sources, global warming, acid rain, and adverse health effects. This is an institutional barrier to increasing energy efficiency. Some of the key barriers to achieving increased efficiency are listed below.

1.10.1 Lack of Objective Consumer Information

Efficiency claims in the market place are often made by competing manufacturers, without an objective third party to evaluate the actual efficiency claims.

1.10.2 Failure of Consumers to Make Optimal Energy-Efficiency Decisions

Consumers often choose the least expensive appliance, rather than the appliance that will save them money over the long term; consumers are also often confused about efficiency ratings and efficiency improvements.

1.10.3 Replacement Market Decisions Based on Availability Rather Than Efficiency

Decisions concerning replacement of worn out or broken equipment are made without energy efficiency as a high priority. Usually, the primary concern for the consumer is restoring service as quickly as possible. This requires buying whatever equipment the plumbing or heating contractor may have on hand.

1.10.4 Energy Prices do not take into Account the Full Environmental or Societal Costs

External costs associated with public health, energy production, global warming, acid rain, air pollution, energy security, or reliability of supply are usually ignored.

1.10.5 Competition for Capital to Make Energy-Efficiency Investments

Energy-efficiency investments in the commercial and industrial sectors often must compete with other business investments; therefore, efficiency investments with a payback of more than 3 years are avoided.

1.10.6 The Separation of Building Ownership from Utility Bill Responsibility

Renters will rarely make energy-efficiency investments in buildings that they do not own, especially when the utilities are included in the rent.

1.10.7 Commercial Buildings and Retail Space are Usually Built on Speculation with Low First- Cost a Priority

The building's long-term operation cost, which is usually paid by the tenant(s) rather than the owner, is not important to the speculator/builder.

1.11 Role of Energy Managers

"The tasks of energy manger are setting goals, tracking progress, and promoting the energy management program. An Energy Manager helps an organization achieve its goals by establishing energy performance as a core value."

The Energy Manager is not always an expert in energy and technical systems. Successful Energy Manager understands how energy management helps the organization achieve its financial and environmental goals and objectives. Depending on the size of the organization, the Energy Manager role can be a full-time position or an addition to other responsibilities

Energy Manager: Responsibilities and Duties to be Assigned Under The Energy Conservation Act, 2001.

Responsibilities

• Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs

• Establish an energy conservation cell within the firm with management's consent about the mandate and task of the cell.

• Initiate activities to improve monitoring and process control to reduce energy costs.

• Analyze equipment performance with respect to energy efficiency

• Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.

• Prepare information material and conduct internal workshops about the topic for other staff.

• Improve disaggregating of energy consumption data down to shop level or profit center of a firm.

• Establish a methodology how to accurately calculate the specific energy consumption of various products/services or activity of the firm.

• Develop and manage training programme for energy efficiency at operating levels.

• Co-ordinate nomination of management personnel to external programs

• Create knowledge bank on sectoral, national and inter-national development on energy efficiency technology and management system and information denomination

• Develop integrated system of energy efficiency and environmental up gradation.

• Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.

• Establish and/or participate in information exchange with other energy managers of the same sector through association

Duties

• Report to BEE and State level Designated Agency once a year the information with regard to the energy consumed and action taken on the recommendation of the accredited energy auditor, as per BEE Format.

• Establish an improved data recording, collection and analysis system to keep track of energy consumption.

• Provide support to Accredited Energy Audit Firm retained by the company for the conduct of energy audit

• Provide information to BEE as demanded in the Act, and with respect to the tasks given by a mandate, and the job description.

• Prepare a scheme for efficient use of energy and its conservation and implement such scheme keeping in view of the economic stability of the investment in such form and manner as may be provided in the regulations of the Energy Conservation Act

1.12 Energy Audit Instruments

Electrical Measuring Instruments:

These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hertz, kVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

These instruments are applied on-line i.e on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.

Combustion analyzer:

This instrument has in-built chemical cells which measure various gases such as O2, CO, NOX and SOX.

Fuel Efficiency Monitor:

This measures oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calcu- lates the combustion efficiency.

Fyrite:

A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. A separate fyrite can be used for O2 and CO2 measurement

Contact thermometer:
These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream.

For surface temperature, a leaf type probe is used with the same instrument

Infrared Thermometer: This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instru- ment is useful for measuring hot spots in furnaces, surface temperatures etc.

Pitot Tube and manometer:

Air velocity in ducts can be measured using a pitot tube and inclined manometer for fur- ther calculation of flows.

Water flow meter:
This non-contact flow measuring device using Doppler effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

Speed Measurements:
In any audit exercise speed measurements are critical as thay may change with frequency, belt slip and loading.

A simple tachometer is a contact type instru- ment which can be used where direct access is possible.
More sophisticated and safer ones are non contact instruments such as stroboscopes

Leak Detectors:
Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not pos- sible to detect with human abilities

Lux meters:

Illumination levels are measured with a lux meter. It consists of a photo cell which sens- es the light output, converts to electrical impulses which are calibrated as lux.

RENEWABLE ENERGY

1.SOLAR ENERGY

Needless to say that the Sun is the biggest source of renewable energy for the Earth. The fact is that even though the earth receives only a part of the energy generated by the Sun (i.e. Solar energy), that part of solar energy is also tremendously huge. The Earth receives solar energy in the form of light and heat. But in today's world, the words 'power' and 'energy' are leaned more towards 'electricity'

Photovoltaics (PV)

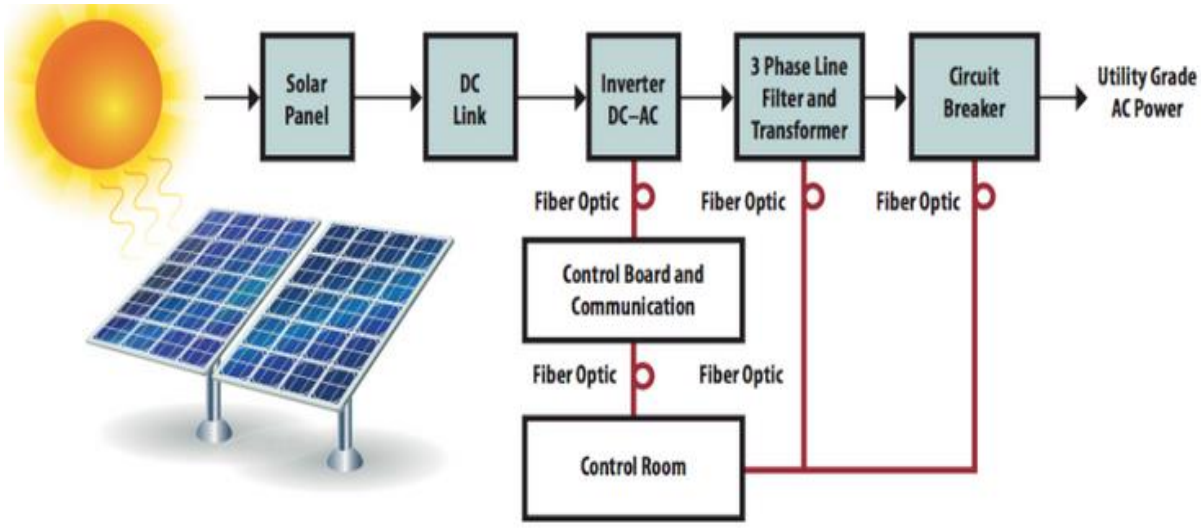
Photovoltaics directly convert **solar energy into electricity**. They work on the principle of the photovoltaic effect. When certain materials are exposed to light, they absorb photons and release free electrons. This phenomenon is called as the photoelectric effect. Photovoltaic effect is a method of producing direct current electricity based on the principle of the photoelectric effect.

Based on the principle of photovoltaic effect, solar cells or photovoltaic cells are made. They convert sunlight into direct current (DC) electricity. But, a single photovoltaic cell does not produce enough amount of electricity. Therefore, a number of photovoltaic cells are mounted on a supporting frame and are electrically connected to each other to form a photovoltaic module or **solar panel**

. Commonly available solar panels range from several hundred watts (say 100 watts) up to few kilowatts (ever heard of a 5kW solar panel?). They are available in different sizes and different price ranges. Solar panels or modules are designed to supply electric power at a certain voltage (say 12v), but the current they produce is directly dependent on the incident light. As of now it is clear that photovoltaic modules produce DC electricity

Photovoltaic solar power system

These systems supply the load only when the Sun is shining. There is no storage of power generated and, hence, batteries are absent. An inverter may or may not be used depending on the type of load.



2.WIND ENERGY

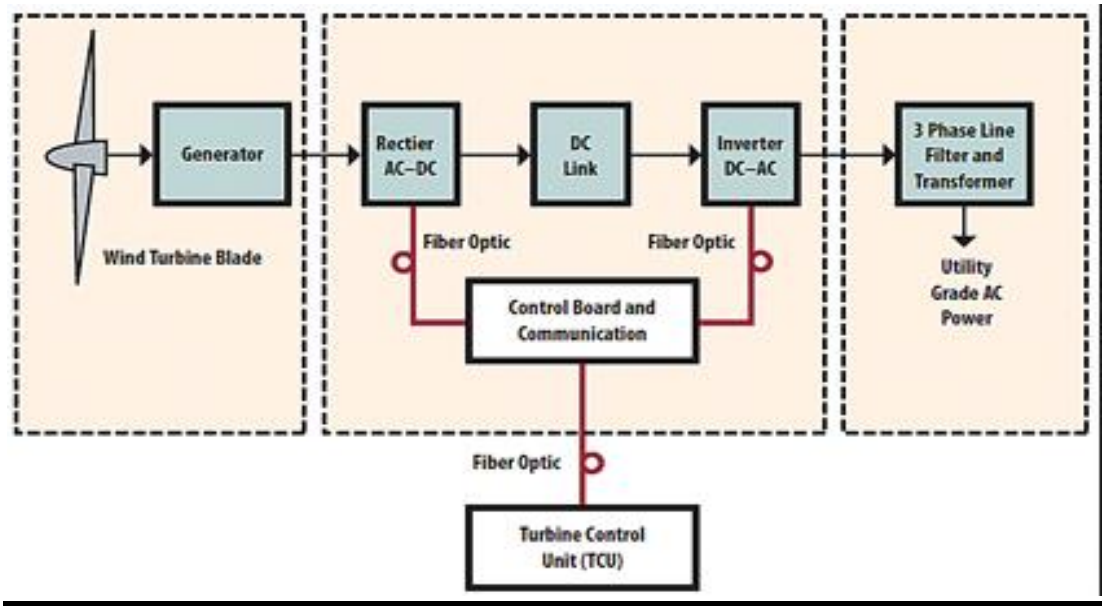
The wind energy is one of the important renewable energy sources. The wind is the movement of air caused due to the uneven distribution of pressure. Earlier times, the wind energy is utilised for the sailing of ships, driving windmills etc .Most of the present application includes the conversion of wind energy into mechanical energy and then to electrical energy. The conversion of wind energy by wind mills uses the component of forces in the direction of wind, known as drag and the forces perpendicular to the direction of wind called lift. Modern designs use both the forces to convert the wind energy into mechanical energy.

Wind Resources

The sun heats up air masses in the atmosphere. The spherical shape of the Earth, the Earth's rotation and seasonal and regional fluctuations of the solar irradiance cause spatial air pressure differentials. These are the source of air movements. Irradiation oversupply at the equator is the source for compensating air streams between the equator and the poles.

PRINCIPLE:

A wind turbine works on a simple principle. This animation shows how energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. Wind turbines are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more above ground, they can take advantage of faster and less turbulent wind. Wind turbines can be used to produce electricity for a single home or building, or they can be connected to an electricity grid (shown here) for more widespread electricity distribution.



SITE SELECTION

- **A.** Technical Considerations
- **B.** *Wind Speed*
- **C.** *Land topography and geology*
- **D.** *Grid structure and distance*
- **E.** *Turbine size*
- **F.** Economic Considerations
- **G.** *Capital cost*
- **H.** *Land cost*
- **I.** *Operational and management cost*
- **J.** *Electricity market*
- **K.** Environmental Considerations
- **L.** *land use*

Wind Energy is a non-conventional energy source having high energy density. The wind energy can be converted into secondary electrical energy by wind turbines. Wind farms are widely used to convert large amount of wind energy into useful secondary energy. Modern wind energy conversion techniques uses both lift and drag forces to produce the motion of the rotor, thereby increasing the conversion efficiencies. The site selection of wind farms is important because technical, economic, environmental and social aspects play a vital role in the selection.